USAFETAC/PR--91/013

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AD-A240 458

AIR WEATHER SERVICE

MARCH AFB
FORECASTING RULES OF THUMB EVALUATION

DTIC ELECTE SEP 17 1991 S B D

by

Capt Brian M. Bjornson

JULY 1991

USAFETAC

Past Weather Our Future

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91-10645

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12 July 1991

REPORT DOCUMENTATION PAGE

2. Report Date: July 1991

3. Report Type: Project Report

4. Title: March AFB Forecasting Rules of Thumb Evaluation

6. Author: Capt Brian M. Bjornson

7. Performing Organization Name and Address: USAF Environmental Technical Applications Center (USAFETAC/DNO), Scott AFB, IL 62225-5358

8. Performing Organization Report Number: USAFETAC/PR--91/013

12. Distribution/Availability Statement: Approved for public release; distribution is unlimited.

13. Abstract: This report documents an evaluation of 23 different "rules of thumb" used in weather forecasting at March AFB, CA. Surface and upper-air data was collected for selected cities in southern California and Nevada. Pressure differences, dew-point temperature, and 850-mb and 500-mb heights were calculated for the selected locations and used to predict ceiling and/or visibility, wind direction, or rain/drizzle events at March AFB. Predictor and predictand variables were identified. The procedure for determining the probability of the predictand, given the predictor, is described, and the accuracy and statistical significance of the results are tested statistically. Frequency distribution tables for each of the 23 rules-of-thumb are given in an appendix.

14. Subject Terms: WEATHER, WEATHER FORECASTING, CLIMATOLOGY, WIND, WIND DIRECTION, CEILING, VISIBILITY, RAIN, DRIZZLE

15. Number of Pages: 20

17. Security Classification of Report: Unclassified

18. Security Classification of this Page: Unclassified

19. Security Classification of Abstract: Unclassified

20. Limitation of Abstract: UL (unlimited) or SAR (same as report)

Standard Form 298

PREFACE

This report documents USAFETAC Project 901052, "March AFB Gradient Wind Study." Project analyst was Capt Brian M. Bjornson, USAFETAC/DNO.

The support assistance request (from Detachment 7, 9th Weather Squadron) asked USAFETAC to verify 23 rules of thumb the detachment was using to forecast ceiling, visibility, wind direction, or rain/drizzle at March AFB. It also requested frequency of occurrence for each of these events, given dew-point temperature at March AFB, certain pressure-surface heights at San Diego, or certain pressure differences between two or more reporting stations in southern California and Nevada.

USAFETAC/DNO collected surface and upper-air data for selected cities. Pressure differences, dew-point temperature, and 850-mb and 500-mb heights were calculated for selected locations and used to predict ceiling and/or visibility, wind direction, or rain/drizzle events at March AFB. USAFETAC/DNO then defined predictor and predictand variables and described the procedure for determining the probability of the predictand, given the predictor. Statistical tests evaluated the accuracy and statistical significance of the results. Frequency distribution tables were developed for each of the 23 rules-of-thumb for all months--these tables are provided in the Appendix.

The results of this study, which indicated that only 13 of the 23 forecasting rules were reliable, are specific to March Air Force Base, California, and are therefore representative of the March AFB area only.

CONTENTS

PURPOSE

The purpose of USAFETAC Project 901052 was to evaluate 23 forecasting rules-of-thumb used to predict ceiling height (CIG), visibility (VSBY), wind direction, and rain/drizzle events at March AFB, CA. Pressure differences (PD) between selected stations in southern California, dew-point temperature at March AFB, and constant-pressure level heights at San Diego are used to predict the frequency of occurrence (probability) of these events. Statistical tests were used to assess the skill and statistical significance of the results.

DATA AND LIMITATIONS

Surface and Upper-Air Data.

Surface weather observations from the stations shown in the table below were used for the study. San Diego upper-air data was also used. Hourly and special observations were included in the dataset. Each station used in the study is listed with its ICAO identifier (CALL), block station number (BLKSTN), latitude (LAT), longitude (LON), and station elevation (ELEV).

STATION	CALL	BLKSTN	LAT°	LON°	ELEV (feet)
Bakersfield, CA	BFL	723840	35.26N	119.03W	490
Dagget, CA	DAG	723815	34.51N	116.47W	1760
George AFB, CA	VCV	723825	34.35N	117.23W	2875
Las Vegas, NV	LAS	723860	36.05N	115.10W	2174
Long Beach, CA	LGB	722970	33.49N	118.09W	57
March AFB, CA	RIV	722860	33.52N	117.15W	1538
Norton AFB, CA	SBD	722866	34.06N	117.14W	1157
San Diego, CA	SAN	722900	32.44N	117.10W	15

Nature of the Data.

An independent dataset (period of record 1973-1985) containing about 160,000 observations was used for independent verification of an earlier "March AFB Gradient Study" by Det 7, 9 WS; this study used a dependent dataset with a 1986-1987 period of record. The independent dataset included sea-level pressure for all stations, 850-mb and 500-mb heights at San Diego, and ceiling height, visibility, present weather, wind speed, and wind direction at March AFB. Det 7 had requested frequency distributions to use in verifying rules of thumb for forecasting ceiling and/or visibility, wind direction, and rain/drizzle.

METHODOLOGY

Definitions.
A "*predictor* variable" (X) is one that predicts; a "*predictand* variable" (Y) is one that is predicted. For meteorological purposes, this means that we know X and want to predict Y.

Predictor Variables.
In this study, the predictor variable (X) is one of the following:

- the pressure difference between SAN and LAS,
- the pressure difference between LGB and DAG,
- the sum of the pressure differences between SAN and LAS, between LGB and DAG, and between SBD and VCV (i.e., the cumulative pressure difference),
- the larger of two sea-level pressures (SLP) between BFL and DAG,
- the RIV dew-point temperature,
- the 850-mb height at SAN, or
- the 500-mb height at SAN.

Predictand Variables.
The predictand variable (Y) is either wind direction, ceiling height and/or visibility, or rain/drizzle at March AFB.

Calculating Predictor and Predictand Variables.
Program modules that use the SAN-LAS PD, LGB-DAG PD, and the cumulative pressure difference (the sum of all three pressure differences) as predictor variables were developed. RIV dew-point temperature, SAN 850 mb height, SAN 500 mb height, and comparisons between sea-level pressure (SLP) at DAG and BFL (i.e., DAG SLP > BFL SLP or BFL SLP > DAG SLP) were also determined for selected times as described in the support assistance request (SAR) and used as predictor variables. For example, in the first table in the Appendix (Table A-1), the predictor variable is the 09Z SAN-LAS PD $\leq$ -3 mb; in Table 13, 22Z RIV dew-point temperature < 30° F is the predictor (note: these are "binary" predictors, meaning that the predictor is or is not met (i.e., "yes" or "no").

Predictand variables were calculated at various times as specified in the SAR. Primarily, predictands were made up of ceiling and/or visibility constraints (e.g., CIG/VSBY < 3,000/3, CIG < 1,000). Ceilings are given in feet MSL; visibilities in statute miles. For example, in Table A-1, the predictand is RIV visibility $\geq$ 5 miles for the entire 12-18Z period. Other predictands include wind direction (knots) and rain/drizzle for selected periods. In Table A-7, the predictand is the occurrence of rain or drizzle at RIV for any hour between 18 and 00Z.

Procedure.
Statistical Analysis System--SAS (a registered trademark of SAS Institute, Inc.) computer programs were written to produce a frequency distribution table for each of the 23 rules-of-thumb for each month (276 tables). The predictor variable was calculated for selected times as described in the SAR. Based on SAR requirements, a flag was set to **1** when the predictor condition is true and to **0** when false.

The next step was to determine the predictand variable during the time period specified in the SAR. A flag was set to **1** when the condition is satisfied and to **0** when it is not satisfied. To illustrate, the first of 10 specific SAR requirements is used: Given the 09Z SAN-LAS PD is $\leq$ -3 mb, what is the percent occurence frequency (POF) that

RIV visibility is ≥ 5 miles for the entire period between 12-18Z? The predictor in this case is the 09Z SAN-LAS PD ≤ -3 mb and the predictand is RIV VSBY ≥ 5 miles for all hours between 12-18Z. Therefore, when the 09Z SAN-LAS PD is ≤ -3 mb, a flag is set to 1; otherwise, it is set to 0. Likewise, when the RIV VSBY ≥ 5 miles for all hours between 12-18Z, a flag is set to 1; otherwise, it is set to 0. A frequency distribution table is then produced to compare the forecast (predictor flag) with the observation (predictand flag). Statistics (see 3.4) are generated to provide information on how well the predictor and predictand compared. The results are discussed in Section 4.

Statistics.

The following monthly statistics were used to verify each of the 23 forecasting rules:

(1) ***Total number of times (N) the predictor variable occurs.*** For example, in the question "determine the percent frequency that RIV visibility is ≥ 5 miles between 12-18Z, given the 09Z SAN-LAS PD is ≤ -3 mb, **N** is the number of times the PD is ≤ -3 mb.

(2) ***Frequency of occurrence (PROB)*** of the constraint as a percentage of the observations for a given *predictor* variable (sometimes called a "hit"). For example, in column "JAN" of Table A-1, N = 162, *PROB* = 0.94 indicates that visibility was ≥ 5 miles 152 of the 162 times the 09Z SAN-LAS PD was ≤ -3 mb.

(3) ***Probability of detection (POD)*** is the percent frequency the constraint occurs for a given predictand variable. In column "JAN" of Table A-2, a POD of 0.60 indicates that 60 percent of the predictand observations occur when the 09Z SAN-LAS PD is ≤ -3 mb; conversely, 40 percent occur when the 09Z SAN-LAS PD is > -3 mb.

(4) ***"P-value" (PVAL)*** is one of the statistics generated from the "chi-square test," which is used to find out if the *observed* frequency distributions differ significantly from *expected* frequency distributions (those that result from chance). The chi-square test shows only if two frequency distributions differ significantly from each other. When chi-square is larger than certain limits, the observed frequency distribution is significantly different from the expected distribution (i.e., the results are not by chance). The level of significance, or PVAL, is used to determine the weight of the difference between observed and expected distributions. P-values less than or equal to 0.01 indicate that the results are almost certainly significant. When the P-value is 0.05, there is one chance in 20 that the forecast could have been made by chance, and this is still considered a reliable result. P-values greater than 0.05 usually indicate that results are not significantly different from chance. For this study, P-values less than or equal to 0.05 are considered statistically significant.

(5) ***The Heidke skill score (HSS)*** is used to assess the skill or accuracy of the results. The equation used is:

$$HSS = \frac{(F-D)}{(T-D)}$$

where

F = number of correct forecasts

T = total number of forecasts

D = number of forecasts expected to be correct based on chance.

The equation for D is:

$$D = \frac{(C1\,R1 + C2\,R2 + \ldots + CnRn)}{T}$$

where

n = number of contingencies

C and R = The sums of the columns and rows taken from the table

T = total number of forecasts.

The HSS normally ranges from zero (no skill) to one (total accuracy), but it can be slightly negative (no skill). In meteorological wind study applications, Heidke skill scores between 0.30 and 0.40 are considered to be satisfactory. An HSS greater than 0.40 indicates good skill, but wind studies conducted in the past have shown that HSSs are typically less than 0.30 (little to no skill). Negative HSSs are shown as 0.00 (no skill) in the tables.

RESULTS

Tables.

Tables A-1 through A-23 in the appendix summarize the key findings of this study. Each table describes each of the 10 specific requirements given in the SAR.

Reliability of Results.

Results of the study are "reliable" or "unreliable," as defined below:

Reliable Results.

"Reliable" results must contain significant probabilities (PROB $\geq$ 0.75) and P-values that indicate statistical significance (PVAL $\leq$ 0.05). The HSS and POD should also be considered, but are not as critical in this study as PROB and PVAL. If results are reliable (as defined here), and HSS or POD are poor (HSS < 0.30 or POD < 0.65), then results can be used to help predict certain events *only* if forecasters limit themselves to the constraints imposed by the predictor variable. For example, in the "MAR" column of Table A-1, PROB (0.94) and PVAL (0.00) are excellent, but the HSS and POD are low (0.23 and 0.20 respectively). Results indicate that if the predictor is met (09Z SAN-LAS PD $\leq$ -3 mb), there is a high probability that VSBY $\geq$ 5 miles for the entire period between 12-18Z. However, visibilities $\geq$ 5 miles occur only 20 percent of the time (POD = 0.20) when the 09Z SAN-LAS PD is $\leq$ -3 mb; visibilities $\geq$ 5 miles occur 80 percent (1 - 0.20) of the time when the 09Z SAN-LAS PD > -3 mb (i.e., the predictor is not met). Although VSBY $\geq$ 5 miles occurs more often when the 09Z SAN-LAS PD is > -3 mb, forecasters can use the statistics only to forecast VSBY $\geq$ 5 miles if the 09Z SAN-LAS PD is $\leq$ -3 mb (i.e., the predictor is met).

If results are reliable (PROB $\geq$ 0.75 and PVAL $\leq$ 0.05) and the HSS and POD are significant (HSS $\geq$ 0.30; POD $\geq$ 0.65), the statistics can be used to help predict events even if the predictor is not met. For example, during December (Table A-9) there is a 0.92 probability that *no* RIV CIG/VSBY is < 3,000/3 for the entire period between 22-04Z, given the 15Z LGB-DAG pressure difference is $\leq$ -2 mb. The POD, PVAL, and HSS are *all* excellent. Therefore, when the predictor is *not* met (i.e., the 15Z LGB-DAG PD > -2 mb), there is a high probability that RIV CIG/VSBY <u>is</u> < 3,000/3 for the entire 22-04Z period. Unfortunately, only 6 months (from all 23 tasks) contain results in which <u>all</u> statistics are significant (Table A-9, JAN and DEC; Table A-13, JUN; Table A-22, JUL and AUG; and Table A-23, AUG). This implies that, for these cases, the information provided can be used regardless of whether or not the predictor is met.

Unreliable Results.
Results are "unreliable" when either of these two conditions are met: (a) PROB is < 0.75; or (b) PVAL > 0.05. Table A-18 provides an example of unreliable results. It is also a good example of why *not* to determine the thresholds of the predictor from a dataset that contains observations only when the predictand is met. When the RIV CIG/VSBY < 500/1 (predictand is met), the cumulative pressure difference is usually ≥ 5 mb (high POD during summer months); however, when the pressure difference ≥ 5 mb (predictor is met), RIV CIG/VSBY is seldom < 500/1 (low PROB during summer months). Therefore, when the PROB is < 0.75, do not use the statistics to make *any* forecast.

Rules Found to be Reliable.
The study showed that 13 of the 23 forecast rules-of-thumb were reliable for certain months, as shown in Tables A-1 and A-2, A-4 and A-5, A-9 and A-10, A- 12 thru A-14, A-16, and A-21 thru A-23). Most of the "reliable" rules (9 out of 13) work best (good skill and high observation count) during the November-February cool season--see Tables A-1 and A-2, A-4 and A-5, A-9 and A-10, A-12, A-14, and A-16. The other four (Table A-13 and Tables A-21 thru A-24) seem to work better during the summer. Some general findings:

- Eight of the nine rules that work best during the cool season have *negative pressure differences* as predictors.

- All four of the rules that work best during summer have predictors *other than pressure differences.*

Rules Found to be Unreliable.
The study found that 10 of the 23 forecasting rules of thumb provide little, if any, guidance for predicting ceiling, visibility, or wind direction at March AFB--see Tables A-3, A-6 thru A-8, A-11, A-15, and A-17 thru A-20. Some general findings:

- Eight of the ten unreliable rules have *positive pressure differences* as predictors.

- Regardless of the predictor variable, RIV CIG/VSBY < 500/1 or RIV CIG < 1,000 feet cannot be predicted using any of the 23 rules of thumb.

SUMMARY

Surface and upper-air data was collected for selected cities in southern California and Nevada. Pressure differences, dew-point temperature, and 850-mb and 500-mb heights were calculated for selected locations and used to predict ceiling and/or visibility, wind direction, or rain/drizzle events at March AFB. Frequency distribution tables were developed for each of 23 rules-of-thumb for all months--see the tables in the Appendix.

CONCLUSIONS

Results indicate that only 13 of the 23 forecasting rules were reliable; most of these (9 out of 13) seem to work best during the cool season. Negative pressure differences between selected cities are good predictors of CIG/VSBY ≤ 3,000/3 or ≥ 3,000/3 at March AFB.

Ten of the rules-of-thumb showed unreliable results. In 8 of these cases, the predictor variable was the positive pressure difference between two or more locations. Results showed that predicting RIV CIG/VSBY < 500/1 or RIV CIG < 1,000, regardless of the predictor variable, is unlikely using *any* of Detachment 7's rules of thumb.

APPENDIX A

TABLE A-1. Percent frequency (PROB) that RIV visibility is ≥ 5 miles for the entire period between 12-18Z, given the 09Z SAN-LAS pressure difference (PD) is ≤ -3 mb. N is the number of times the 09Z PD is ≤ -3 mb; POD is the probability of detection; PVAL is the corresponding p-value from the chi-square test; HSS is the corresponding Heidke skill score.

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
N	162	99	34	22	8	8	0	2	24	64	111	167
PROB	0.94	0.87	0.94	0.95	0.88	0.88	N/A	0.50	0.92	0.91	0.96	0.95
POD	0.60	0.46	0.20	0.12	0.06	0.06	N/A	0.01	0.13	0.35	0.49	0.60
PVAL	0.00	0.00	0.00	0.00	0.00	0.00	N/A	0.70	0.00	0.00	0.00	0.00
HSS	0.48	0.39	0.23	0.12	0.08	0.08	N/A	0.00	0.13	0.36	0.43	0.47

TABLE A-2. Percent frequency (PROB) that RIV ceiling/visibility is < 3000/3 for the entire period between 10-16Z, given the 3Z LGB-DAG pressure difference (PD) is ≤ -2 mb. N is the number of times the 3Z PD is ≤ -2 mb; POD is the probability of detection; PVAL is the corresponding p-value from the chi-square test; HSS is the corresponding Heidke skill score.

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
N	153	81	21	6	2	4	4	2	14	46	113	181
PROB	0.96	0.95	0.90	1.00	0.50	0.75	0.50	0.50	1.00	0.96	0.97	0.96
POD	0.62	0.42	0.14	0.04	0.01	0.02	0.01	0.01	0.08	0.28	0.49	0.64
PVAL	0.00	0.00	0.00	0.00	0.45	[illegible]	0.82	0.96	0.00	0.00	0.00	0.00
HSS	0.53	0.40	0.16	0.05	0.01	0.03	0.00	0.00	0.08	0.31	0.43	0.50

TABLE A-3. Percent frequency (PROB) that RIV ceiling/visibility is < 500/1 for any hour between 10-16Z, given the 3Z LGB-DAG pressure difference (PD) is ≥ 3 mb. N is the number of times the 3Z PD is ≥ 3 mb; POD is the probability of detection; PVAL is the corresponding p-value from the chi-square test; HSS is the corresponding Heidke skill score. **Question 9a(7a).**

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
N	56	75	189	251	339	342	339	306	202	98	62	42
PROB	0.46	0.48	0.35	0.31	0.41	0.34	0.17	0.23	0.34	0.45	0.44	0.57
POD	0.27	0.36	0.52	0.77	0.96	0.99	0.95	0.92	0.75	0.34	0.29	0.29
PVAL	0.00	0.00	0.12	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00
HSS	0.20	0.23	0.07	0.13	0.15	0.11	0.05	0.09	0.22	0.14	0.19	0.29

TABLE A-4 Percent frequency (PROB) that RIV ceiling/visibility is < 3000/3 for the entire period between 16-22Z, given the 9Z LGB-DAG pressure difference (PD) is ≤ -2 mb. N is the number of times the 9Z PD is ≤ -2 mb; POD is the probability of detection; PVAL is the corresponding p-value from the chi-square test; HSS is the corresponding Heidke skill score. **Question 9a(6b).**

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
N	70	50	18	7	1	3	0	2	14	23	69	88
PROB	1.00	0.92	1.00	1.00	1.00	1.00	N/A	0.50	0.93	1.00	0.99	0.98
POD	0.43	0.37	0.18	0.06	0.01	0.03	N/A	0.01	0.13	0.26	0.50	0.52
PVAL	0.00	0.00	0.00	0.00	0.13	0.06	N/A	0.81	0.00	0.00	0.00	0.00
HSS	0.35	0.33	0.21	0.07	0.02	0.03	N/A	0.00	0.14	0.29	0.42	0.36

TABLE A-5. Percent frequency (PROB) that RIV ceiling/visibility is ≥ 3000/3 for the entire period between 18-00Z, given the 15Z cumulative pressure difference (CD) is ≤ -10 mb. N is the number of times the 15Z CD is ≤ -10 mb; POD is the probability of detection; PVAL is the corresponding p-value from the chi-square test; HSS is the corresponding Heidke skill score.

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
N	75	51	14	13	8	6	1	0	13	33	56	80
PROB	0.99	0.94	0.93	0.92	0.88	1.00	1.00	N/A	1.00	0.94	0.94	0.99
POD	0.51	0.42	0.14	0.10	0.09	0.06	0.01	N/A	0.10	0.26	0.44	0.48
PVAL	0.00	0.00	0.00	0.00	0.00	0.00	0.51	N/A	0.00	0.00	0.00	0.00
HSS	0.46	0.38	0.16	0.09	0.09	0.07	0.01	N/A	0.09	0.24	0.40	0.35

TABLE A-6. Percent frequency (PROB) that RIV ceiling is < 3000 feet for any hour between 18-00Z, given the 15Z cumulative pressure difference (CD) is ≥ 0 but < 5 mb. N is the number of times the 15Z CD is 0 < 5 mb; POD is the probability of detection; PVAL is the corresponding p-value from the chi-square test; HSS is the corresponding Heidke skill score (Oct-Apr only).

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
N	44	37	48	36						57	35	37
PROB	0.41	0.59	0.33	0.28						0.32	0.37	0.32
POD	0.24	0.31	0.16	0.13						0.38	0.21	0.25
PVAL	0.09	0.00	0.23	0.57						0.01	0.13	0.03
HSS	0.10	0.25	0.00	0.00						0.16	0.09	0.14

TABLE A-7. Percent frequency (PROB) that RIV will have rain or drizzle for any hour between 18-00Z, given the 15Z cumulative pressure difference (CD) is ≥ 5 mb. N is the number of times the 15Z CD is ≥ 5 mb; POD is the probability of detection; PVAL is the corresponding p-value from the chi-square test; HSS is the corresponding Heidke skill score (Oct-Apr only).

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
N	42	54	117	138						45	54	35
PROB	0.50	0.19	0.19	0.09						0.1[illegible]	0.24	0.20
POD	0.53	0.42	0.82	0.92						1.00	0.93	0.37
PVAL	0.00	0[illegible]	0.14	0.01						0.00	0.00	0.00
HSS	0.42	[illegible]	0.15	0[illegible]						0.17	0.32	0.17

TABLE A-8. Percent frequency (PROB) that RIV ceiling/visibility is < 500/1 for any hour between 10-16Z, given the 21Z SAN-LAS pressure difference (PD) is > 5 mb. N is the number of times the 21Z PD is > 5 mb; POD is the probability of detection; PVAL is the corresponding p-value from the chi-square test; HSS is the corresponding Heidke skill score (Mar-Oct only).

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
N			145	180	84	241	152	113	74	52		
PROB			0.28	0.28	0.37	0.35	0.33	0.34	0.30	0.40		
POD			0.33	0.50	0.58	0.71	0.77	0.51	0.25	0.16		
PVAL			0.34	0.46	0.84	0.06	0.00	0.00	0.10	0.24		
HSS			0.00	0.03	0.01	0.08	0.30	0.23	0.08	0.05		

TABLE A-9. Percent frequency (PROB) that no RIV ceiling/visibility is < 3000/3 for the entire period between 22-04Z, given the 15Z LGB-DAG pressure difference (PD) is ≤ -2 mb. N is the number of times the 15Z PD is ≤ -2 mb; POD is the probability of detection; PVAL is the corresponding p-value from the chi-square test; HSS is the corresponding Heidke skill score.

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
N	169	120	51	28	10	14	3	1	30	98	151	199
PROB	0.95	0.90	0.86	0.93	0.90	1.00	0.67	0.00	0.93	0.85	0.86	0.92
POD	0.65	0.56	0.26	0.13	0.06	0.08	0.01	0.00	0.15	0.46	0.61	0.69
PVAL	0.00	0.00	0.00	0.00	0.00	0.00	0.74	0.30	0.00	0.00	0.00	0.00
HSS	0.53	0.48	0.25	0.12	0.07	0.09	0.00	0.00	0.14	0.40	0.48	0.52

TABLE A-10. Percent frequency (PROB) that no RIV ceiling/visibility is < 3000/3 for the entire period between 04-10Z, given the 21Z LGB-DAG pressure difference (PD) is ≤ -2 mb. N is the number of times the 21Z PD is ≤ -2 mb; POD is the probability of detection; PVAL is the corresponding p-value from the chi-square test; HSS is the corresponding Heidke skill score.

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
N	144	89	30	22	9	9	2	5	20	56	101	168
PROB	0.97	0.93	0.90	0.91	0.89	1.00	1.00	0.60	0.95	0.95	0.95	0.97
POD	0.56	0.43	0.15	0.09	0.05	0.05	0.01	0.01	0.09	0.28	0.42	0.59
PVAL	0.00	0.00	0.00	0.00	0.00	0.01	0.39	0.66	0.00	0.00	0.00	0.00
HSS	0.44	0.36	0.14	0.07	0.06	0.04	0.00	0.00	0.07	0.28	0.34	0.45

TABLE A-11. Percent frequency (PROB) that RIV ceiling/visibility is < 500/1 for any hour between 10-16Z, given the 21Z LGB-DAG pressure difference (PD) is ≥ 3 mb. N is the number of times the 21Z PD is ≥ 3 mb; POD is the probability of detection; PVAL is the corresponding p-value from the chi-square test; HSS is the corresponding Heidke skill score.

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
N	59	89	199	233	297	298	290	245	164	97	82	51
PROB	0.54	0.47	0.33	0.34	0.42	0.35	0.21	0.25	0.36	0.46	0.48	0.63
POD	0.32	0.44	0.52	0.77	0.86	0.95	0.97	0.81	0.64	0.35	0.41	0.38
PVAL	0.00	0.00	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HSS	0.26	0.26	0.03	0.16	0.13	0.12	0.11	0.13	0.20	0.16	0.27	0.37

TABLE A-12. Percent frequency (PROB) that no RIV ceiling/visibility is < 3000/3 for the entire period between 10-18Z, given the 22Z RIV dew point temperature is < 30°F. N is the number of times the 22Z dew point is < 30°F; POD is the probability of detection; PVAL is the corresponding p-value from the chi-square test; HSS is the corresponding Heidke skill score.

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
N	138	96	49	45	12	1	0	0	9	51	144	161
PROB	0.91	0.88	0.88	0.96	0.92	1.00	N/A	N/A	1.00	0.90	0.90	0.94
POD	0.53	0.47	0.33	0.30	0.11	0.01	N/A	N/A	0.05	0.27	0.56	0.56
PVAL	0.00	0.00	0.00	0.00	0.00	0.16	N/A	N/A	0.00	0.00	0.00	0.00
HSS	0.44	0.43	0.37	0.35	0.15	0.01	N/A	N/A	0.06	0.29	0.45	0.43

TABLE A-13. Percent frequency (PROB) that RIV ceiling/visibility is ≤ 1000/3 for the entire period between 10-18Z, given the 22Z RIV dew point temperature is ≥ 50°F. N is the number of times the 22Z dew point is ≥ 50°F; POD is the probability of detection; PVAL is the corresponding p-value from the chi-square test; HSS is the corresponding Heidke skill score.

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
N	41	53	70	99	188	266	333	331	291	150	45	27
PROB	0.85	0.83	0.93	0.77	0.86	0.79	0.53	0.55	0.59	0.86	0.87	0.74
POD	0.23	0.24	0.26	0.36	0.58	0.82	0.91	0.89	0.87	0.55	0.23	0.14
PVAL	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HSS	0.23	0.20	0.20	0.23	0.34	0.46	0.20	0.20	0.29	0.41	0.24	0.15

TABLE A-14. Percent frequency (PROB) that RIV ceiling/visibility is ≥ 3000/3 for the entire period between 09-15Z, given the 03Z cumulative pressure difference (CD) is ≤ -10 mb. N is the number of times the 03Z CD is ≤ -10 mb; POD is the probability of detection; PVAL is the corresponding p-value from the chi-square test; HSS is the corresponding Heidke skill score.

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
N	67	31	7	3	1	2	1	0	3	15	39	71
PROB	0.99	1.00	1.00	1.00	1.00	1.00	1.00	N/A	1.00	1.00	1.00	0.99
POD	0.50	0.29	0.10	0.03	0.01	0.03	0.01	N/A	0.02	0.15	0.31	0.43
PVAL	0.00	0.00	0.00	0.03	0.11	0.04	0.43	N/A	0.09	0.00	0.00	0.00
HSS	0.46	0.30	0.13	0.04	0.02	0.03	0.00	N/A	0.02	0.18	0.30	0.33

TABLE A-15. Percent frequency (PROB) that RIV ceiling is < 1000 feet for any hour between 09-15Z, given the 03Z cumulative pressure difference (CD) is 0 < 5 mb. N is the number of times the 03Z CD is 0 < 5 mb; POD is the probability of detection; PVAL is the corresponding p-value from the chi-square test; HSS is the corresponding Heidke skill score (Oct-Apr).

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
N	38	39	45	33						59	56	39
PROB	0.50	.28	0.29	0.09						0.27	0.38	0.28
POD	0.36	0.20	0.16	0.05						0.25	0.36	0.33
PVAL	0.00	0.58	0.67	0.04						0.83	0.01	0.00
HSS	0.29	0.04	0.00	0.00						0.01	0.17	0.19

TABLE A-16. Percent frequency (PROB) that RIV will have rain or drizzle for any hour between 09-15Z, given the 03Z cumulative pressure difference (CD) is ≥ 5 mb. N is the number of times the 03Z CD is ≥ 5 mb; POD is the probability of detection; PVAL is the corresponding p-value from the chi-square test; HSS is the corresponding Heidke skill score (Oct-Apr only).

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
N	35	34	39	20						8	16	20
PROB	0.43	0.76	0.87	1.00						1.00	0.69	0.45
POD	0.27	0.38	0.23	0.11						0.09	0.17	0.25
PVAL	0.00	0.00	0.00	0.01						0.00	0.00	0.00
HSS	0.18	0.37	0.15	0.06						0.11	0.18	0.24

TABLE A-17. Percent frequency (PROB) that RIV ceiling/visibility is < 500/1 for any hour between 10-16Z, given the 03Z cumulative pressure difference (CD) is 0 < 5 mb. N is the number of times the 03Z CD is 0 < 5 mb; POD is the probability of detection; PVAL is the corresponding p-value from the chi-square test; HSS is the corresponding Heidke skill score (May-Oct).

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
N					13	9	32	47	61	59		
PROB					0.00	0.00	0.00	0.04	0.11	0.49		
POD					0.00	0.00	0.00	0.05	0.18	0.36		
PVAL					0.01	0.06	0.05	0.01	0.26	0.00		
HSS					0.00	0.00	0.00	0.00	0.00	0.19		

TABLE A-18. Percent frequency (PROB) that RIV ceiling/visibility is < 500/1 for any hour between 10-16Z, given the 03Z cumulative pressure difference (CD) is ≥ 5 mb. N is the number of times the 03Z CD is ≥ 5 mb; POD is the probability of detection; PVAL is the corresponding p-value from the chi-square test; HSS is the corresponding Heidke skill score (May-Oct).

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
N					233	225	214	186	135	87		
PROB					0.40	0.30	0.11	0.19	0.22	0.45		
POD					0.99	1.00	1.00	0.92	0.79	0.49		
PVAL					0.00	0.00	0.03	0.01	0.00	0.00		
HSS					0.11	0.07	0.04	0.07	0.13	0.19		

TABLE A-19. Percent frequency (PROB) that no RIV ceiling/visibility is < 1000/3 for the entire period between 10-16Z, given the 03Z cumulative pressure difference (CD) is > -10 mb but < 0 mb. N is the number of times the 03Z CD is -10 < 0 mb; POD is the probability of detection; PVAL is the corresponding p-value from the chi-square test; HSS is the corresponding Heidke skill score (May-Oct).

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
N					13	9	4	10	38	81		
PROB					0.23	0.11	0.00	0.40	0.02	0.33		
POD					0.02	0.01	0.00	0.04	0.01	0.20		
PVAL					0.00	0.00	0.11	0.73	0.00	0.00		
HSS					0.00	0.00	0.00	0.00	0.00	0.00		

TABLE A-20. Percent frequency (PROB) that the wind direction at RIV will be between 020 to 060 degrees (inclusive) with minimum wind speeds of 10 knots, given a greater sea level pressure (SLP) at DAG than at BFL (DAG SLP > BFL SLP). N is the number of times DAG SLP > BFL SLP; POD is the probability of detection; PVAL is the corresponding p-value from the chi-square test; HSS is the corresponding Heidke skill score (Oct-May only).

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
N	291	269	131	73	54					113	172	228
PROB	0.35	0.23	0.07	0.21	0.00					0.19	0.48	0.35
POD	0.73	0.78	0.60	0.75	0.00					0.70	0.83	0.72
PVAL	0.00	0.00	0.00	0.00	0.63					0.00	0.00	0.00
HSS	0.24	0.19	0.08	0.30	0.00					0.17	0.41	0.25

TABLE A-21. **Percent frequency (PROB) that the wind direction at RIV will be between 300 to 340 degrees (inclusive) with minimum wind speeds of 10 knots, given a greater sea level pressure (SLP) at BFL than at DAG (BFL SLP > DAG SLP).** N is the number of times BFL SLP > DAG SLP; POD is the probability of detection; PVAL is the corresponding p-value from the chi-square test; HSS is the corresponding Heidke skill score (all months provided due to high PROB).

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
N	323	318	380	455	463	539	593	535	241	207	202	274
PROB	0.27	0.39	0.33	0.55	0.73	0.84	0.83	0.82	0.74	0.60	0.38	0.35
POD	0.94	0.89	0.80	0.94	0.90	0.91	0.94	0.91	0.81	0.75	0.92	0.92
PVAL	0.00	0.00	0.03	0.00	0.22	0.03	0.00	0.03	0.00	0.00	0.00	0.00
HSS	0.24	0.32	0.06	0.17	0.05	0.08	0.11	0.08	0.35	0.23	0.33	0.30

TABLE A-22. **Percent frequency (PROB) that no RIV ceiling < 1000 feet for the entire period between 10-16Z, given the 00Z SAN 850 mb height ≥ 1510 m.** N is the number of times the 00Z 850 mb height ≥ 1510 m; POD is the probability of detection; PVAL is the corresponding p-value from the chi-square test; HSS is the corresponding Heidke skill score (all months provided due to high PROB).

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
N	210	182	87	113	96	215	350	336	192	213	213	225
PROB	0.85	0.84	0.69	0.82	0.75	0.77	0.89	0.88	0.82	0.83	0.85	0.92
POD	0.52	0.52	0.29	0.30	0.28	0.64	0.88	0.84	0.51	0.56	0.57	0.58
PVAL	0.04	0.00	0.66	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HSS	0.08	0.15	0.00	0.06	0.13	0.30	0.37	0.30	0.14	0.21	0.17	0.17

TABLE A-23. **Percent frequency (PROB) that no RIV ceiling < 1000 feet for the entire period between 10-16Z, given the 00Z SAN 500 mb height ≥ 5910 m.** N is the number of times the 00Z 500 mb height ≥ 5910 m; POD is the probability of detection; PVAL is the corresponding p-value from the chi-square test; HSS is the corresponding Heidke skill score (May-Oct only).

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
N					7	133	239	247	82	25		
PROB					0.57	0.86	0.89	0.94	0.94	1.00		
POD					0.02	0.44	0.68	0.66	0.25	0.08		
PVAL					0.91	0.00	0.00	0.00	0.00	0.00		
HSS					0.00	0.28	0.19	0.32	0.12	0.05		

GLOSSARY

BFL	Call sign for Bakersfield
C	Sums of observations in columns of a frequency table
CALL	Station Identifier
CIG	Ceiling height in feet
D	Number of forecasts expected to be correct based on chance
DAG	Call sign for Dagget
ELEV	Station elevation in feet
F	Number of correct forecasts in a frequency table
HSS	Heidke skill score
LAS	Call sign for Las Vegas
LAT	Latitude in degrees
LGB	Call sign for Long Beach
LON	Longitude in degrees
mb	Millibar
MS	Mean sea level
N	Total occurrences of a predictor variable
PD	Pressure difference in millibars
POD	Probability of detection
PROB	Frequency of occurrence or probability
PVAL	P-value
R	Sums of observations in rows of a freqency table
RIV	Call sign for March AFB
SAN	Call sign for San Diego
SAR	*Support Assistance Request*
SBD	Call sign for Norton AFB
SLP	Sea level pressure in millibars
T	Total number of forecasts in a frequency table
VCV	Call sign for George AFB
VSBY	Visibility in statute miles
WMO	World Meteorological Organization
X	Predictor variable
Y	Predictand variable
Z	Zulu--Greenwich mean time

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